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(54) Method of controlling the  
operation of an automatic washing  
machine

(57) A method of controlling the opera-  
tion of an automatic clothes or dish  
washing machine comprises measuring  
the surface tension and/or the water  
hardness and/or the electrical conduc-  
tivity and/or the pH value of the  
washing liquid for the machine, and  
regulating the volume of water supplied  
to the machine and/or the number of  
changes of such water, and/or the  
metering of at least one additive in  
dependence on the measurement(s)  
made.

GB 2 052 251 A

1/2

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FIG.1

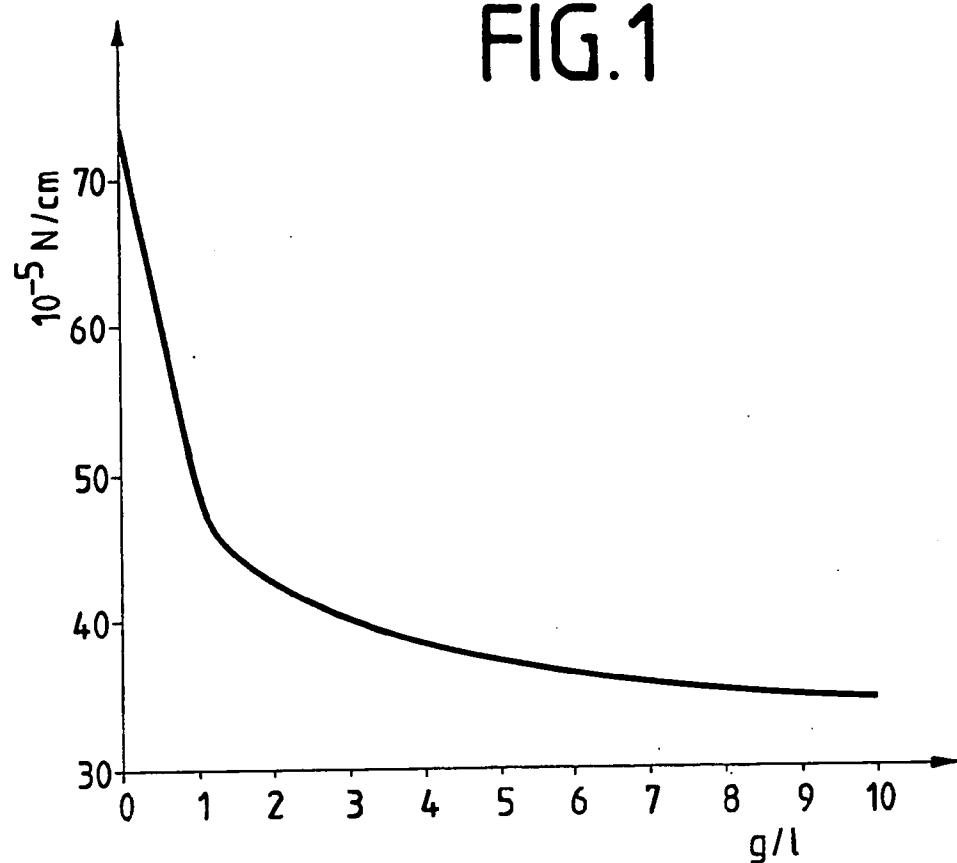
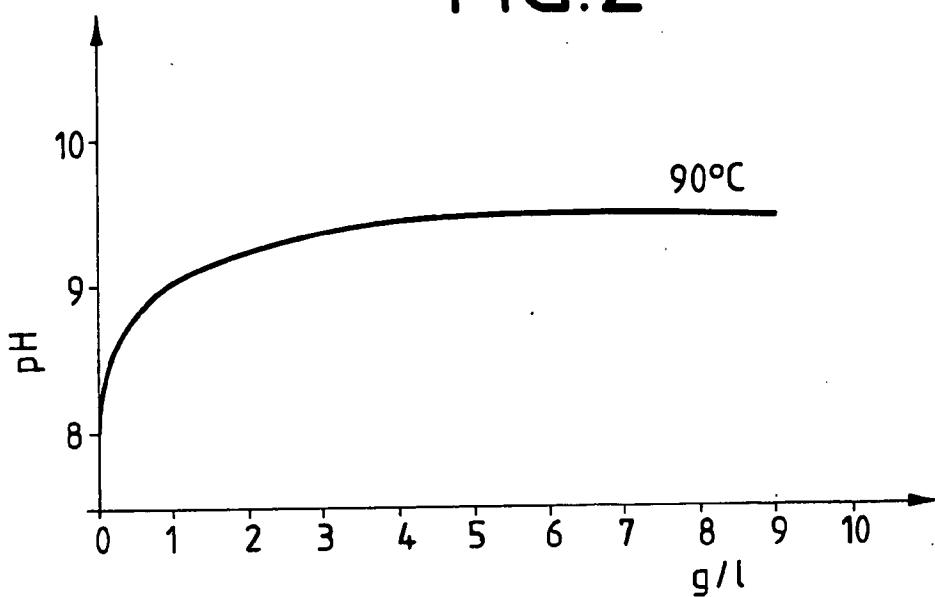


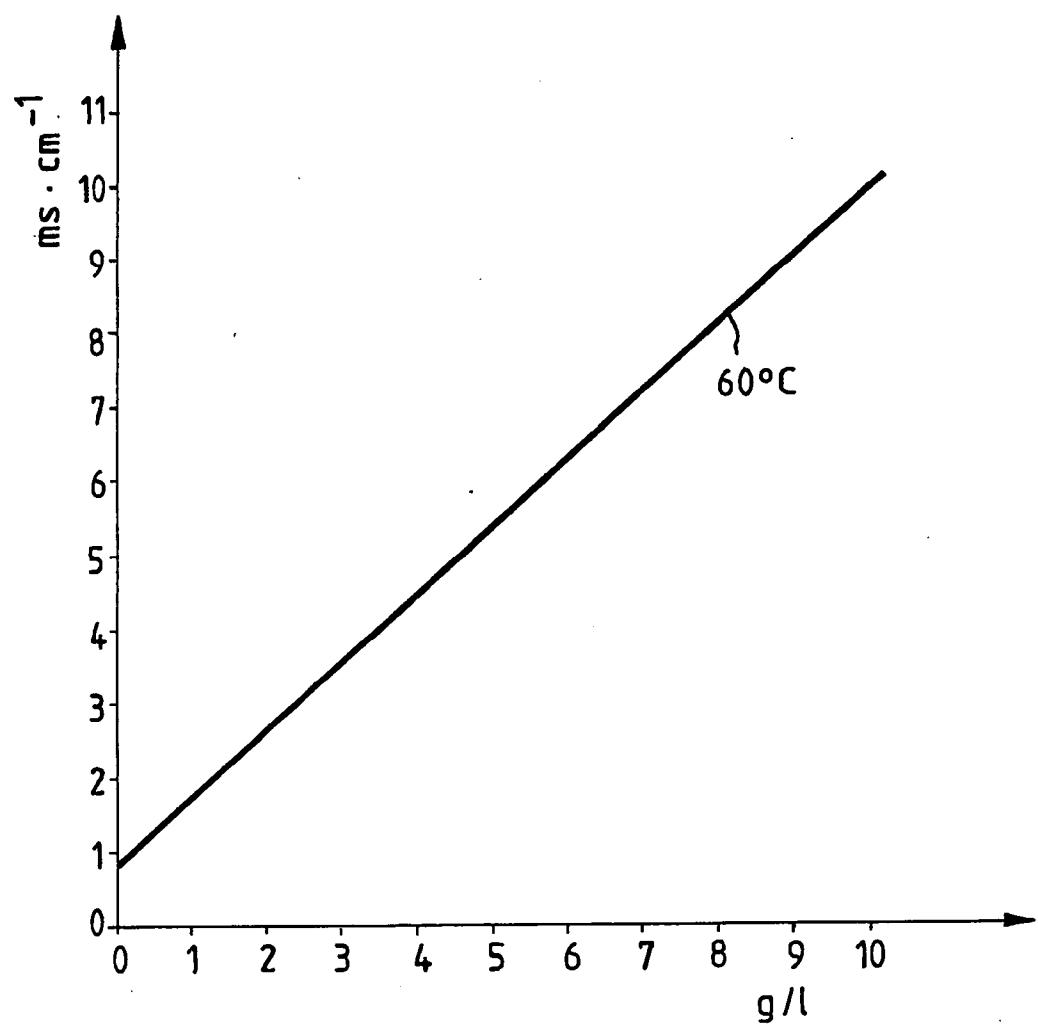
FIG.2



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2/2

FIG.3



## SPECIFICATION

**Method of monitoring and controlling the operation of an automatic washing machine**

5 The present invention relates to a method of monitoring and controlling an operating program, especially the water feed and/or the addition of cleaning or rinsing agents, of an automatic clothes or dish

10 washing machine.

In automatic washing machines available on the market, a particular quantity of washing powder selected for the preliminary and main wash according to the prescription of the washing agent manufacturer, or the generally used rinsing agent for a particular rinsing operation, is introduced before the start of the washing process into chambers of a rinsing tub. The chambers, which are connected with a water connection and the rinsing container of the

15 machine, are rinsed and emptied under programmed operation of the machine, so that for certain washing operations the associated cleaning or rinsing agent is supplied to the rinsing container and the water content thereof.

20 25 In addition, the known automatic washing machines contain a program selector switch for setting of the desired program, which is related to the nature of the laundry to be washed and the degree of soiling of the laundry articles, and program control device, in which appropriate laundering programs are stored by mechanical and/or electrical means in such a manner that during the machine operation the water feed, heating, laundry movement and water drainage are carried out in the

25 30 35 desired sequence.

The commercially available laundering agents contain different effective substances, which are present in particular weight proportion ratios. In general, the complex phosphate content of such an agent is sufficiently high for the agent to meet washing requirements at, for example, water hardnesses of about 20° dH. Since this water hardness is present in only a few parts of the country, an excess amount of phosphates is usually employed in

40 45 50 55 washing operations in the soft water regions. This leads to unnecessary waste of the effective substance and additional environmental pollution. On the other hand, if the metering recommendations for lower water hardness regions are followed, then the washing operation can in some cases be carried out with an insufficient amount of detergent, which means that the laundry is not washed properly. In addition, although laundering agent manufacturer provide metering recommendations on packaging of the agents, there is a tendency for users to use an excess amount of the agent when adding the agent by hand, which leads to pollution of the environment.

In German (Fed. Rep.) patent specification No. 25 54 592, there is disclosed a method of laundering textiles, in which separately stored effective substances or combinations thereof (for example, active substances for washing, framework substances, bleaching agents, catalysts, organic acids and soft

60 65 70 75 80 85 90 95 100 105 110 115 120 125 pumpable form to the washing liquid before or during the washing process. On the presumption that the effective substances of the washing agent are present in separate, pumpable form, the quantity of framework substances or phosphates to be added is adjusted, depending on the water hardness at the site of the machine, during the installation of the machine according to instructions of the machine manufacturer.

There is accordingly a need for a method which with energy-saving and environmentally compatible operation of the machine, provides a good cleaning result and wherein the metering of additives depends on the water hardness, the quantity and the degree of soiling of the articles to be washed by the machine.

According to the present invention there is provided a method of monitoring and controlling an operating program of an automatic washing machine, the method comprising the steps of measuring at least one of the surface tension, water hardness and electrical conductivity of washing liquid for the machine with the aid of measuring means of the machine and so controlling the machine program by electrical control means in dependence on such measurement as to control at least one of the volume of water supplied to the machine, the number of changes of such water and the metering of at least one additive.

In such a method, washing and rinsing agents dissolved in the water lower the surface tension of the washing liquid and increase electrical conductivity, as well as increase the pH-value in dependence on the concentration of agents in the liquid.

Examples of the present invention will now be more particularly described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a graph with a plotted line showing the dependence of washing liquid surface tension on the concentration in the liquid of a washing agent;

Figure 2 is a graph with a plotted line showing the dependence of the pH-value of the liquid on the concentration therein of the washing agent at a certain temperature; and

Figure 3 is a graph with a plotted line showing the dependence of the specific electrical conductivity of a washing liquid at 60°C of the washing agent concentration.

Referring now to the drawings, mains water fed to a clothes or dish washing machine has a higher surface tension which is strongly reduced by the smallest additions of surface-active substances. This effect is provided in washing agents by all the usual active substances, such as soaps, ionic or anionic tensides, and is the basis and a prerequisite for all successful washing operations. For the performance of a washing operation which is optimal with respect to result, rationality and automation considerations, the concentration of the washing agent can be adjusted by controlling the surface tension to be a predetermined value. In addition, by measurement of the surface tension it can be determined how many rinsing operations are needed. The sensitivity of the regulating magnitude at low washing agent

regulating operations by the measurement magnitude "surface tension". This measurement magnitude includes the adhesive force associated therewith. The measurement of the surface tension can 5 take place by a known method, for example by bubble pressure measurement, use of a tensiometer or stactometer, or by the height of rise method.

Trials have shown that the addition of a washing agent for the performance of a complete washing 10 program in a commercially available automatic washing machine can be stopped once a surface tension of the washing liquid of  $37.10^{-5}$  N/cm (37 dynes/cm) has been reached. As a surface tension of  $69.10^{-5}$  N/cm was measured after a fourth rinsing 15 operation and this value corresponded to a washing agent concentration which did not exceed the permissible residual content of washing agent content, a fifth rinsing operation - which normally is automatically provided in a conventional automatic washing 20 machine - is not needed.

The pH-value of mains water is increased up to a certain value by the quantity of the washing agent. This increase is dependent on concentration, as shown in Figure 2 for a washing agent at 90°C. For 25 the washing operation, the optimum concentration for a typical washing agent is about 5 grams per litre. A certain pH-value corresponds to this value at a certain temperature. If this pH-value is not present at the start of the washing, the washing agent concentration 30 is too low compared with the optimum concentration. By means of a sensor measuring the pH-value, the agent concentration can be brought to the desired value. This also applies to further metering in the event that the agent is consumed 35 during the washing. Similarly, such a sensor can be utilised for limitation of the number of rinsing operations, for example when the pH-value during the rinsing operations approaches or equals the pH-value of the incoming mains water. The monitoring 40 of the pH-value can be performed in a simple and known manner, for example with a pH-value measuring device and a single rod measuring electrode as a sensor. The signal delivered by the sensor can, however, be fed directly to the control circuit for 45 the program course.

To monitor the pH-value, the pH-sensor can be incorporated in a commercially available type of automatic washing machine so that it is in contact with the washing liquid or the rinsing water. During 50 a washing operation at 90°C with household articles soiled with, for example, fat, a washing agent is initially added until the pH-value of the liquid is 9.5, thus at the value which corresponds to the optimum concentration. During the course of the washing 55 program, the pH-value drops to 9.3 due to consumption of the agent, whereupon a further quantity of the agent is added until the pH-value is again 9.5. As a result there is neither over use nor under use of the agent. After the fourth rinsing operation, the rinsing 60 water has a pH-value of 7.2, which is equal to the pH-value of the mains water used. The entire rinsing operation, originally controlled by the program switching mechanism to provide five individual rinsing cycles, can thus be stopped after the fourth 65 rinsing cycle, which corresponds to a water saving of

about 19 litres yet provides a good overall washing result.

Mains water possesses a certain electrical conductivity by virtue of the salts dissolved therein. Since 70 washing agents, due to the dissociable components contained therein, appreciably increase the electrical conductivity of the water in dependence on concentration, the measurement of conductivity is particularly suitable for use in terminating the rinsing 75 operation in a washing machine. When the value of the conductivity of the mains water has been reached in the rinsing water, then the soiling components and the cleaning agent residues have been removed from the rinsing container and the articles 80 being washed, and further rinsing cycles are not needed. The conductivity measurement can be carried out with commercially available measuring devices and conductivity measuring electrodes as a sensor.

85 In an advantageous manner, the pH-value of the washing liquid is measured to enable metering of the washing agent to an optimum agent concentration, and the electrical conductivity of the liquid is measured and compared with that of the fresh water 90 for determination of the degree of cleanliness of the liquid in the course of the individual rinsing operations.

## CLAIMS

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1. A method of monitoring and controlling an operating program of an automatic washing machine, the method comprising the steps of measuring at least one of the surface tension, water hardness and electrical conductivity of washing liquid for the machine with the aid of measuring means of the machine and so controlling the machine program by electrical control means in dependence on such measurement as to control at least one of the volume of water supplied to the machine, the number of changes of such water and the metering of at least one additive.
2. A method as claimed in claim 1, wherein the step of measuring comprises measuring at least one of the surface tension, adhesive force, electrical conductivity or pH-value of the washing liquid with the aid of at least one sensor arranged in at least one measuring location in the machine.
3. A method as claimed in either claim 1 or claim 110 2, wherein the step of controlling comprises transmitting measurement magnitudes to the electrical control means for comparison with predetermined magnitudes and determination or variation of at least one of the supplied water volume, the number 115 of changes of the water and the metered quantity of at least one additive.
4. A method as claimed in any one of the preceding claims, wherein the step of measuring comprises measuring the surface tension of the washing water by a tensiometer or a stactometer.
5. A method as claimed in any one of claims 1 to 3, wherein the step of measuring comprises measuring the surface tension of the washing liquid by measuring at least one of the bubble pressure in the water and the height of rise of the water.

6. A method as claimed in any one of the preceding claims, wherein the step of measuring comprises measuring the electrical conductivity of the washing liquid, the method comprising the 5 further step of terminating one of a washing operation and a rinsing operation of the machine in dependence of the measured conductivity.

7. A method as claimed in any one of the preceding claims, wherein the step of measuring 10 comprises measuring the pH-value of the washing liquid and the step of controlling comprises setting the concentration of a washing agent in dependence on the measured pH-value.

8. A method as claimed in claim 7, wherein the 15 step of measuring further comprises measuring the electrical conductivity of each washing liquid during operation of the machine and fresh water to be used in the machine and the step of controlling comprises comparing measured amounts of conductivity of the 20 washing liquid with those of the fresh water and metering the supply of washing agent in dependence on the comparison result.

9. A method of monitoring and controlling an 25 operation program of an automatic washing machine, the method being substantially as hereinbefore described with reference to the accompanying drawings.